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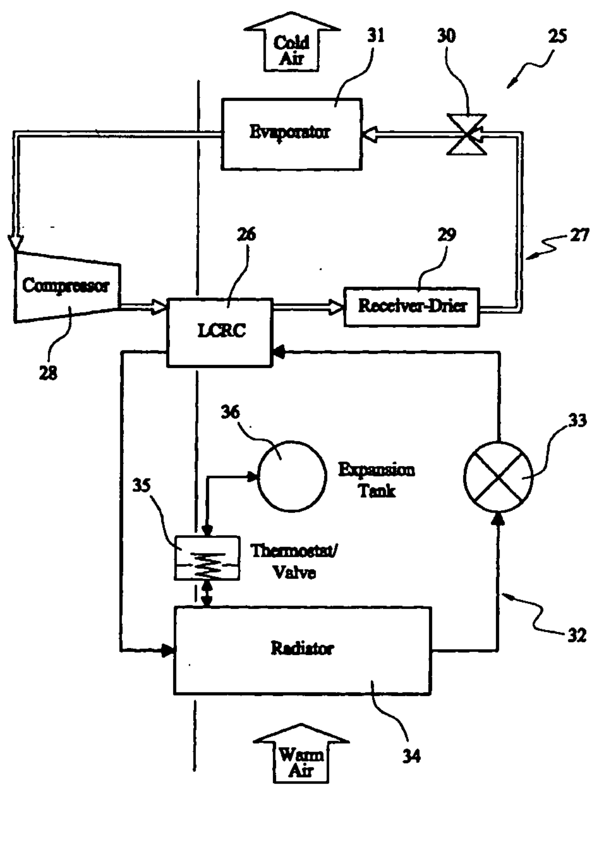
(54) Title: AUTOMOTIVE CONDENSER ARRANGEMENT AND AUTOMOTIVE HEAT EXCHANGER SYSTEM



(57) Abstract: An automotive condenser (26) system (particularly for an automotive air conditioning or refrigerant system) has a refrigerant flowpath and a liquid coolant flowpath in thermal heat transfer contact with the refrigerant flowpath. The condenser (26) is typically the primary condenser (26) used in an automotive air conditioning or refrigerant circuit (27) to dissipate heat from the refrigerant. This enables a conventional, larger, "air flow" condenser to be replaced.

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Automotive Condenser Arrangement and Automotive Heat Exchanger System

The present invention relaters to an automotive condenser arrangement and an automotive heat exchanger system.

Modern trends in automotive development place a premium on space available internally of the vehicle engine compartment. Consequently the ability to reduce the overall envelope (shape and size) of components mounted internally of the engine compartment, without compromising performance unduly, is at a premium. Improved automotive apparatus has now been devised.

According to a first aspect, the present invention provides an automotive condenser arrangement (particularly for an automotive air conditioning or refrigerant system) comprising:

(i) a refrigerant flowpath; and,

(ii) a liquid coolant flowpath in thermal heat transfer contact with the refrigerant flowpath.

The condenser is preferably the primary condenser used in an automotive air conditioning or refrigerant circuit to dissipate heat from the refrigerant. This enables a conventional, larger, "air flow" condenser to be replaced. For corresponding performance, a comparable "air flow" condenser would need to be considerably larger than a liquid coolant condenser according to the invention.

The refrigerant and liquid coolant flowpaths preferably comprise portions of respective sealed fluid circuit systems.

The refrigerant flowpath beneficially comprises a first gallery system, and the liquid coolant flowpath comprises a second gallery system, the first and second gallery systems being substantially sealed from one another.

The gallery systems are preferably defined by a plurality of stacked elements the elements preferably having correspondingly tapering peripheral walls facilitating nesting. The peripheral walls of the nesting elements beneficially define the outer wall of the heat exchanger.

It is preferred that galleries in respective gallery systems are of differing depths.

The stacked elements defining the gallery systems desirably comprise nested shell and/or plate elements spaced to define the respective gallery systems.

In one embodiment the nested elements may comprise nested dimpled shell elements, each including a plurality of spaced dimples formed in and projecting away from the major face of the respective shell element.

In an alternative embodiment a shell element may be stacked with adjacent shell elements in nested relationship, respective turbulator elements being nested within the respective shell elements.

The liquid coolant in the liquid coolant flowpath is preferably water.

According to a second aspect, the invention provides an automotive heat exchanger arrangement having a refrigeration or air conditioning system comprising a refrigerant circuit including:

(i) a condenser comprising a refrigerant flowpath and a liquid coolant flowpath in thermal heat transfer contact with the refrigerant flowpath; and,

(ii) an evaporator in a refrigerant circuit with the condenser.

The refrigerant circuit beneficially further includes one or more of:

(a) a compressor;

(b) an expansion valve;

(c) receiver drier arrangement.

The liquid coolant flowpath of the condenser is preferably in a circuit with a further heat exchanger arranged to cool the liquid coolant. The further heat exchanger may comprise an air cooled radiator (particularly suited for vehicular applications). The radiator is arranged to perform heat transfer on vehicle engine coolant.

The invention will now be described in specific embodiments

by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of an exemplary automotive condenser arrangement according to the invention;

Figure 2 is a schematic sectional view of the condenser arrangement of figure 1;

Figure 3 is a schematic perspective view of a first arrangement of stacked elements comprising an exemplary condenser arrangement;

Figure 4 is a schematic perspective view of a second embodiment of element for comprising an exemplary stacked element condenser arrangement;

Figure 5 is a schematic view of a first embodiment of air conditioning/refrigeration system according to the invention;

Figure 6 is a schematic view of an alternative embodiment of air conditioning/refrigeration system according to the invention.

Referring to the drawings and initially to figures 1 to 4, the condenser 1 comprises a series of nested stacked metallic shells 2, bonded to form the structure shown in Figure 1. The stacked shells 2, define therebetween first and second sealed gallery systems in alternating layers.

A "water side" gallery system communicating between a water inlet 5 communicating through a top plate 6 of the condenser and a water outlet 4. The second gallery system also defined by the shells 2 comprises a "refrigerant side" gallery system communicating between a refrigerant inlet 7 and a refrigerant outlet (not shown in Figure 1) communicating via base plate 8.

As will be described in detail hereafter, the gallery system is arranged such that the stacked arrangement has "water side (coolant)" galleries alternating with "refrigerant side" galleries. Adjacently arranged shell plates 2 are rotated through 180 degrees with respect to one another such that downwardly projecting rims of apertures 10a,10b abut upwardly projecting rims of apertures 9a,9b to define the gallery systems and water and refrigerant cores communicating between respective galleries in each system.

A turbulator plate 13 is sandwiched between adjacently stacked shell plates 2. The turbulator plate 13 may comprise a pressed metallic component having a plurality of apertured ridge formations extending generally transversely to the major face of the turbulator plate, the ridges including a multiplicity of apertures permitting fluid (water coolant or refrigerant) flow throughout the gallery. The upper surface of the turbulator plate 13 is contiguous with the underside of an overlaid shell 2. The underside of turbulator plate 13 is bonded to the planar surface of an underlaid shell 2. The turbulator plates 13 are nested in respective plain shells 2 during assembly. The side

walls 21 of shells 2 are inclined upwardly and outwardly from the major face of the shell element 2. The sidewalls extend upwardly beyond the top surface of turbulator plate 13 permitting the nesting of an overlaying shell 2 within the side wall 21.

As an alternative to using a separate turbulator plate, the shells 2 may be formed to include turbulating projections which also serve to separate the adjacent shell elements. A dimpled shell as shown for example in figure 4 may be used.

Dimpled shell 2 includes a spanning portion 23 terminating in an outwardly and upwardly inclined peripheral wall 21. Spanning portion 23 is provided with an array of dimpled projections 15, projecting upwardly in the corresponding direction to peripheral wall 21. On its obverse side spanning portion 23 is provided with a series of dimpled depressions (resulting from the deformation of plate 13 during the forming of the dimples 15). Apertures 9a,9b, 10a,10b in dimpled shell 2 correspond to the apertures in the plain shell element 2 described above.

The fluids may flow in the same direction or opposing directions. The fluid paths may be single pass, two pass or multi-pass through the condenser. The inlet and outlet ports may be mounted to the top plate or base plate.

Heat is transferred from the higher temperature refrigerant, through the thin walls of the shell elements

2, to the cooling liquid. The fitted turbulator or dimpled shells, break up the laminar flow of the fluids to increase efficiency by mixing local hot and cold regions in each fluid. The turbulator 13 and dimples 15 also provide a secondary heat transfer surface, which conduct heat directly out of the refrigerant, and transfer it into the cooling liquid. The form of the turbulator 13 and dimples 15 are tuned to suit the refrigerant and cooling liquid properties, in order to maximise fluid mixing and minimise fluid pressure drop through the condenser.

The heat transfer from the refrigerant to the cooling liquid is normally sufficient to produce a change of state in the refrigerant, transforming it from a high pressure high temperature gaseous phase into a high pressure lower temperature liquid phase.

The use of a liquid cooled refrigerant condenser according to the invention rather than a conventional air-cooled condenser has the following advantages:

- The cooling liquid will generally have a considerably higher density (ρ) and specific heat capacity (Cp) than air. This gives the potential for a much greater heat transfer from the refrigerant in a smaller more compact condenser. For example, if water is used as the cooling medium, the comparison is:

-

Air - $\rho = 1.177\text{kgm}^{-3}$, $Cp = 1.0049\text{kJkg}^{-1}\text{K}^{-1}$ @ 27°C

Water - $\rho = 1000\text{kgm}^{-3}$, $Cp = 4.18\text{kJkg}^{-1}\text{K}^{-1}$ @ 27°C

- The smaller more compact configuration (stacked plate/shell) permits the condenser to be packaged in locations that optimise hose routings, where an adequate current of cooling air is not available to an air-cooled condenser.
- The condenser may be mounted closely with the compressor, which itself may not be in a convenient location for a current of cooling air. This allows for shorter high pressure refrigerant hose routings that an air-cooled condenser.

- The liquid cooled refrigerant condenser permits lengthy high pressure high cost refrigerant hoses and fittings needed for air cooled arrangements to be replace by low pressure low cost cooling liquid hoses and fittings, with a corresponding reduction in system refrigerant volume.

The liquid cooled refrigerant condenser of the present invention is particularly suited to replace a conventional air cooled condenser in a refrigeration or air conditioning system where performance requirements are high and spatial considerations important (such as for example for vehicle based systems). For a given heat transfer performance requirement, it can be shown that a liquid cooled refrigerant condenser provides a more compact heat exchanger solution than an air cooled condenser of equivalent performance.

Examples of such improved systems are shown in figures 5

and 6, described in more detail below.

In the refrigeration/air conditioning system 25 of figure 5, liquid cooled refrigerant condenser 26 is included in a conventional refrigeration/air conditioning circuit 27, which includes a compressor 28, receiver drier 29, expansion valve 30 and evaporator 31. Cooled air is output from evaporator 31 to be directed to the required space to be cooled (vehicle cabin etc) in a conventional manner.

The system includes a liquid cooling circuit 32 for recirculating the liquid coolant. The liquid cooling circuit includes a cooling liquid pump 33, the coolant circuit portion of the liquid cooled refrigerant condenser 26, a radiator (air cooled) 34, and a thermostat/valve 35 and expansion tank 36 associated with the radiator.

When the system is used for vehicle applications, the liquid cooling circuit 32 could form an auxiliary low temperature cooling system, isolated from the main engine cooling system, using a separate pump, air conditioning radiator, thermostat/valve and expansion tank. Individual placement and arrangement of the cooling circuit components may vary, according to particular packaging requirements.

The system starts with the pump 33 that pumps cooling liquid from the liquid cooled refrigerant condenser 26 to the radiator 34, where the liquid cools releasing the heat energy absorbed in the liquid cooled refrigerant condenser 26. Cooling is achieved by the passage of a forced or natural convection current of air over the radiator tubes, and a series of adjoining cooling fins. The cooled liquid

then re-enters the liquid cooled refrigerant condenser 26 to extract more heat from the refrigerant.

During operation, the cooling liquid expands in the circuit due to an overall bulk temperature rise, and the system pressure rises accordingly. At a predetermined pressure the thermostat/valve 35 opens, releasing excess volume coolant into the expansion tank 36. As the bulk temperature of the coolant falls, coolant from the expansion bottle is drawn back into the cooling system.

Referring now to the system shown in figure 6. In the system shown the liquid coolant circuit for the air conditioning/refrigerant system is integrated into the main engine cooling circuit of a vehicle, rather than forming an isolated cooling system. Here the auxiliary air conditioning/refrigerant radiator of the system of Figure 5 is replaced with a sub-cooled section 44 of the main engine-cooling radiator 45. This enables both systems to use the same single coolant pump 43, radiator 45, expansion tank 46 and coolant. Individual placement and arrangement of the cooling circuit components may vary, according to particular packaging and pressure balance requirements. For example, the thermostat/valve 47 upstream of the coolant pump may be positioned at the outlet of the engine, or it may be replaced by a more complex coolant flow control module.

In this system arrangement, flow in the air conditioning/refrigerant cooling circuit is controlled by the second thermostat/valve 48 downstream of the sub-cooled portion of the radiator. At a predetermined coolant

temperature, refrigerant pressure, or air conditioning/refrigerant system activation, the thermostat/valve 48 opens allowing coolant to flow into the liquid cooled refrigerant condenser 26 where heat is transferred to the coolant from the refrigerant. The warm coolant enters the engine coolant pump 43 and flows through the engine 50, where further heat is transferred to it from the combustion process. The hot coolant next passes to the radiator 45 where cooling takes place in the same way as a conventional engine cooling system.

The bulk of the coolant exits the main portion of the radiator to begin the engine cooling cycle again passing through thermostat valve 47. A portion of the coolant passes from the radiator to the sub-cooled portion where further cooling by the passage of a current of air takes place. This lower temperature coolant passes through the thermostat/valve, and the air conditioning/refrigerant cooling circuit begins again.

Expansion of the coolant in the air conditioning/refrigerant cooling system is absorbed by the main engine cooling circuit. The expansion process of the coolant through the expansion tank 46 then takes place in the same way as a conventional engine cooling circuit.

In vehicle applications, the absence of an air-cooled condenser mounted in front of the radiator allows the radiator to work more efficiently. The condenser and system of the present invention permits this. In conventional vehicle applications, the air-cooled condenser obstructs the passage of air to the radiator, reducing the airflow

onto the radiator.

In a conventional system employing an air cooled condenser mounted forward of a radiator, the radiator dissipates the heat released by the refrigerant in the condenser, as the warmed air stream passes to the radiator. In the present system, the radiator must also dissipate the heat released by the refrigerant to the coolant in the liquid cooled refrigerant condenser 26, but it is able to operate in a free airstream. Therefore, there is potential to reduce the size and cost of the radiator accordingly.

CLAIMS:

1. An automotive condenser arrangement comprising:
   (i) a refrigerant flowpath; and,
   (ii) a liquid coolant flowpath in thermal heat transfer contact with the refrigerant flowpath.

2. A condenser arrangement according to claim 1, wherein the refrigerant flowpath comprises a first gallery system, and the liquid coolant flowpath comprises a second gallery system, the first and second gallery systems being substantially sealed from one another.

3. A condenser according to claim 2, wherein the gallery systems are defined by a plurality of stacked elements.

4. A condenser according to claim 3, wherein the stacked elements defining the gallery systems comprise nested shell and/or plate elements spaced to define the respective gallery systems.

5. A condenser according to claim 4, wherein the nested elements comprise:
   (i) nested dimpled shell elements, each including a plurality of spaced dimples formed in and projecting away from the major face of the respective shell element; and/or,

   (ii) shell elements stacked with adjacent shell

elements in nested relationship, respective turbulator elements being nested within the respective shell elements.

6. A condenser according to any of claims 2 to 5, wherein galleries in respective gallery systems are of differing depths.

7. A condenser according to claim 5, wherein the dimpled shell element includes a peripheral wall, the plain shell element nesting within the peripheral wall of the dimpled shell element.

8. A condenser according to claim any preceding claim in which the gallery systems are defined by a plurality of stacked elements the elements having correspondingly tapering peripheral walls facilitating nesting.

9. A condenser according to claim 8, wherein the peripheral walls of the nesting elements define the outer wall of the heat exchanger.

10. A condenser according to any preceding claim, wherein the liquid coolant in the liquid coolant flowpath is water.

11. A condenser according to any preceding claim comprising a condenser of an automotive heat exchange system.

12. An automotive heat exchanger arrangement having a refrigeration or air conditioning system comprising a

refrigerant circuit including:

(i) a condenser comprising a refrigerant flowpath and a liquid coolant flowpath in thermal heat transfer contact with the refrigerant flowpath; and,

(ii) an evaporator in a refrigerant circuit with the condenser.

13. An arrangement according to claim 12, wherein the liquid coolant flowpath condenser comprises the primary (or only) condenser in the refrigerant circuit.

14. An arrangement according to claim 12 or claim 13, wherein the refrigerant circuit includes a compressor.

15. An arrangement according to any of claims 12 to 14, wherein the refrigeration circuit includes an expansion valve.

16. An arrangement according to any of claims 12 to 15, further including a receiver drier arrangement.

17. A heat exchanger arrangement according to any of claims 12 to 16, wherein the liquid coolant flowpath of the condenser is in a circuit with a further heat exchanger arranged to cool the liquid coolant.

18. A heat exchanger arrangement according to claim 17, wherein the further heat exchanger comprises a radiator arranged to cool engine coolant.

19. A heat exchanger arrangement according to claim 18, wherein the refrigerant coolant and engine coolant are provided in respective circuits having a common flowpath portion.

20. A heat exchanger arrangement according to claim 18 or claim 19, wherein the radiator includes a sub cooled radiator portion having a takeoff for the refrigerant coolant.

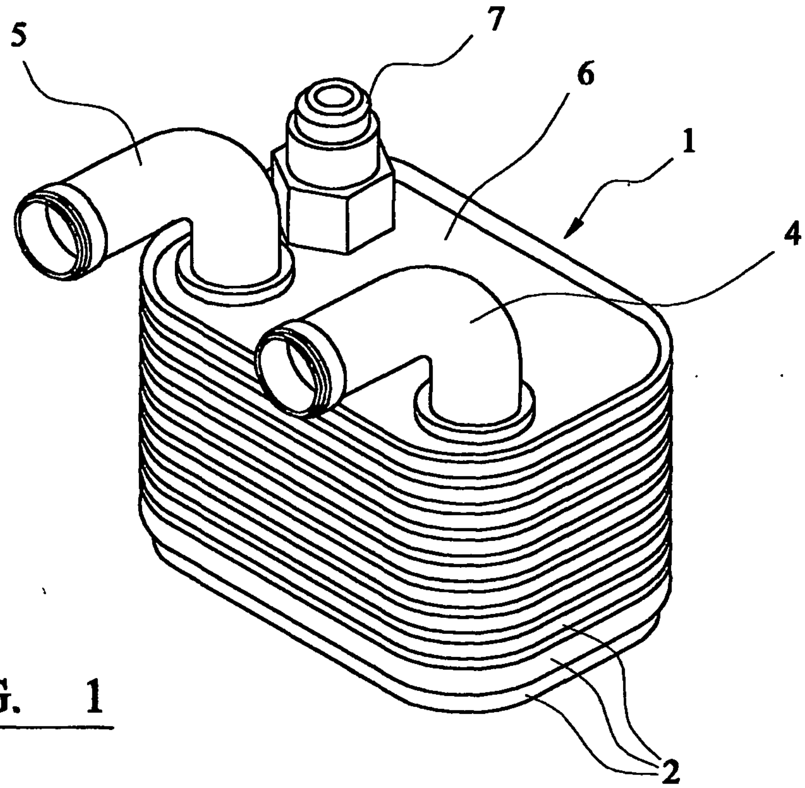


FIG. 1

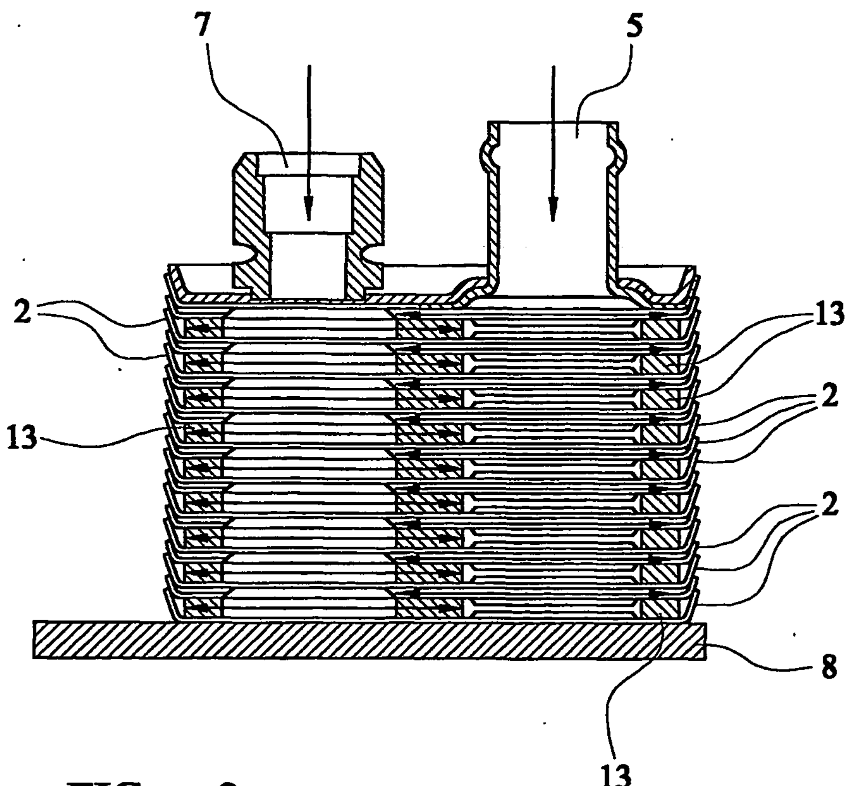


FIG. 2

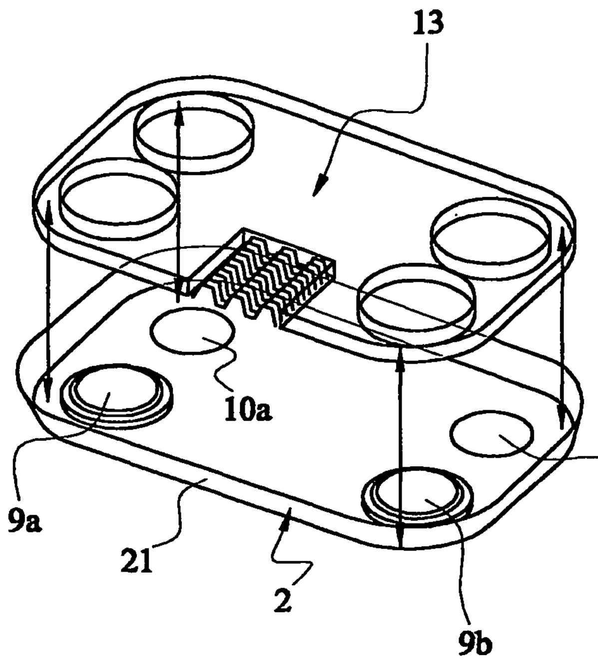


FIG. 3

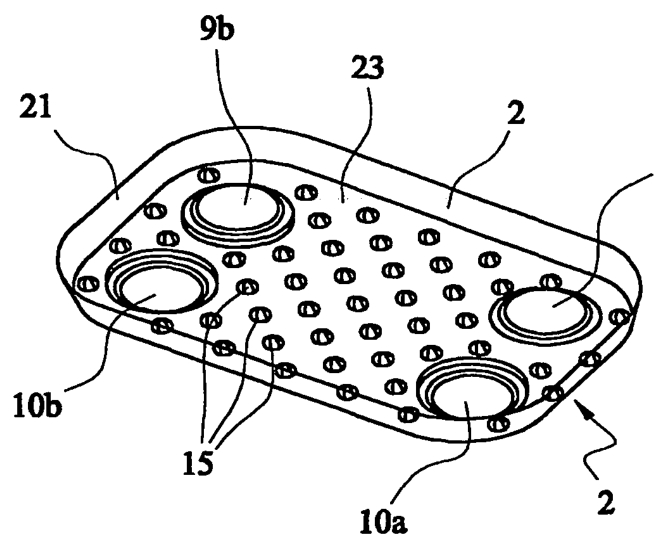
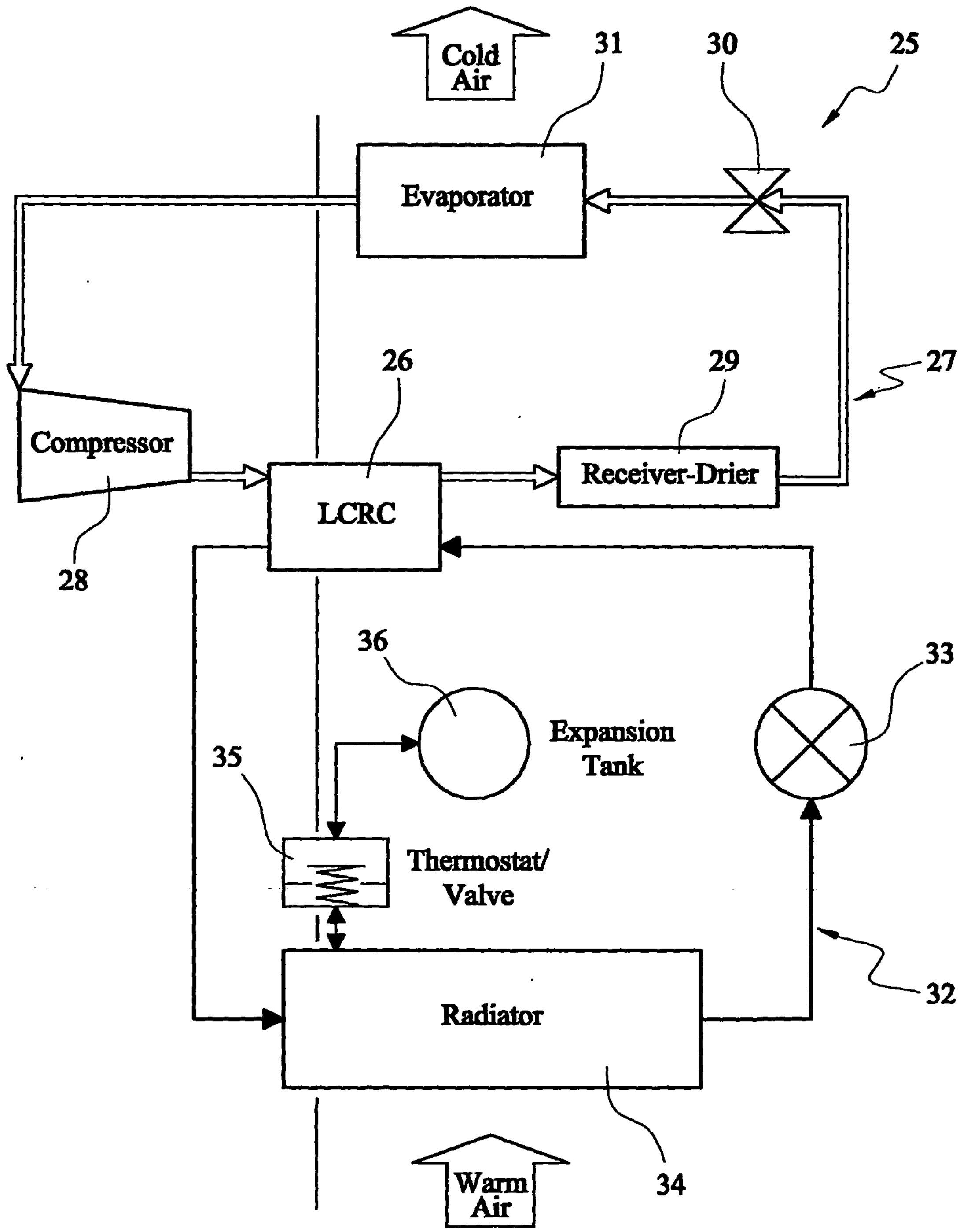


FIG. 4



Cold Air
31
30
25
Evaporator
26
29
27
Compressor
LCRC
Receiver-Drier
28
36
33
35
Expansion Tank
Thermostat/ Valve
32
Radiator
34
Warm Air

FIG. 5

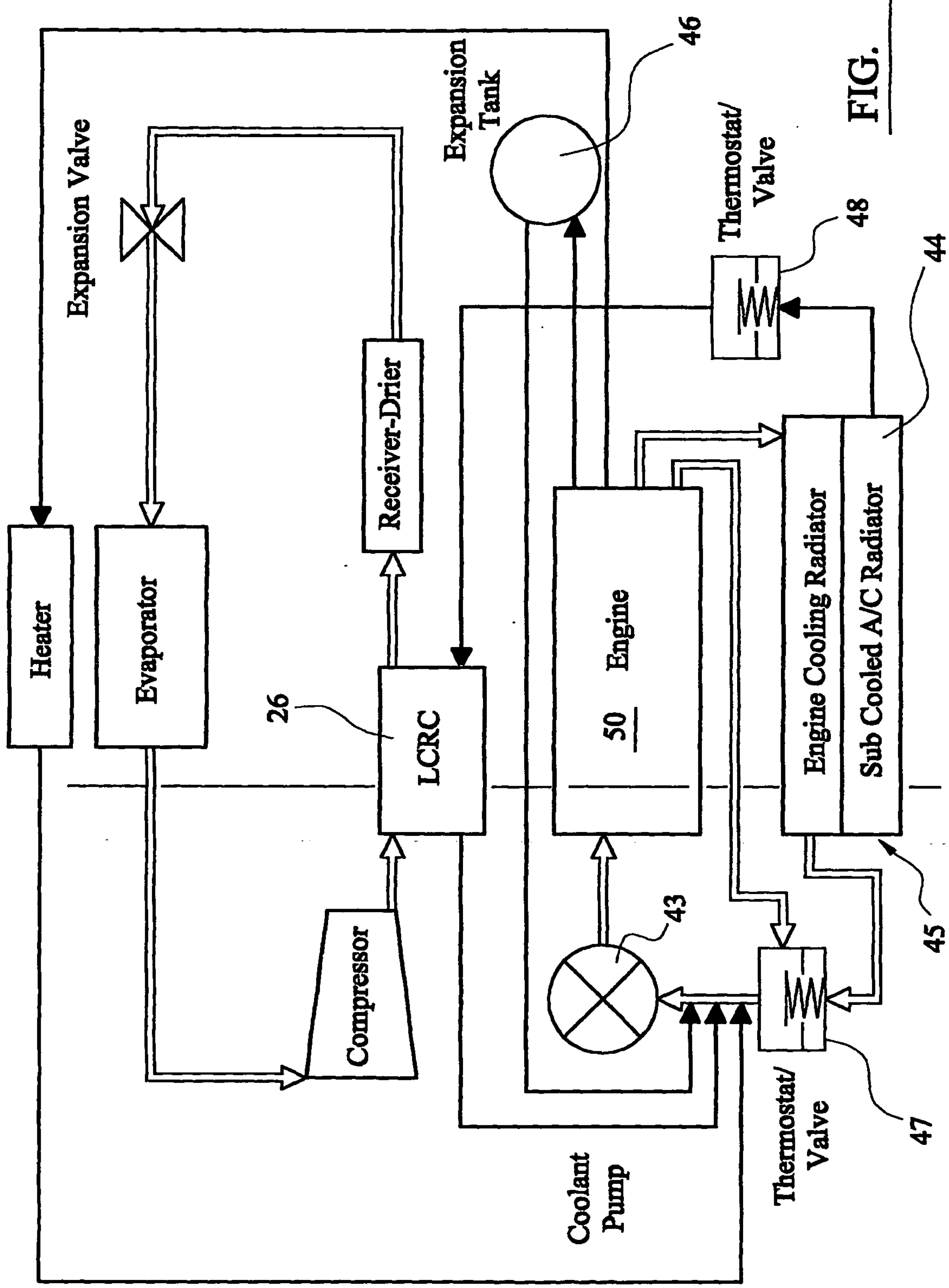

Expansion Valve
Receiver-Drier
Heater
Evaporator
26
LCRC
Compressor
Expansion Tank
46
Engine
50
Thermostat/ Valve
48
44
Engine Cooling Radiator
Sub Cooled A/C Radiator
45
43
47
Thermostat/ Valve
Coolant Pump

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/02235

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F28D9/00 B60H1/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60H F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 03692 A (MERTENS KLAUS ;VALEO THERMIQUE MOTEUR (FR)) 28 January 1999 (1999-01-28)	1,10-20
Y	page 3, last paragraph -page 7; figures	2-9
Y	EP 0 742 418 A (LAENGERER & REICH GMBH & CO) 13 November 1996 (1996-11-13) column 2, line 47 - line 51 column 5, line 14 -column 6, line 42; figures 5-7	2-9
X	DE 43 41 756 A (BEHR GMBH & CO) 14 June 1995 (1995-06-14) column 2, line 59 -column 4, line 26; figures	1,10-18

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
20 September 2001	28/09/2001

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Int   ional Application No
PCT/GB 01/02235

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 46550 A (SWEP INTERNATIONAL AB ;ANDERSSON SVEN (SE); DAHLBERG THOMAS (SE)) 16 September 1999 (1999-09-16) page 1, paragraph 2; figures	2-4,8,9

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Information on patent family members

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